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Protective Actions in the Late Phase - Intervention Criteria and Decision-making

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Abstract

Major countermeasures in the late phase of a nuclear or radiological accident where long-lived radionuclides have been dispersed in the environment are *relocation/resettlement*, *foodstuff restrictions, agricultural countermeasures* and *cleanup* of contaminated areas. A short overview of late phase countermeasures is given together with the recommendations from the international radiation protection organisations ICRP, IAEA and from the EU on the levels of their introduction. The derivation of these intervention levels is briefly addressed.

Decisions on late phase countermeasures include factors or attributes describing benefits from the countermeasure and those describing harm. In analysing the inputs to the decision, it is necessary to decide on the relative importance of each factor. Although there has essentially been a broad acceptance internationally of the principles for intervention, it has not been possible to reach agreement for the purpose of defining a net benefit based upon the exact weighting to be attached to each of the attributes influencing the decision to take a protective action. Major attributes would include those related to radiological protection, and those related to social and psychological issues. Some of these attributes are discussed in the paper and the role of radiation protection in the final decision-making process is elaborated in some detail.

It is concluded that optimisation of the overall health protection is *not* a question of developing radiation protection philosophy to fully include socio-psychological factors. It is rather a question of including these factors - in parallel with the radiological protection factors - in cooperation between radiation protection experts and *e*.g. experts in social and psychological sciences under the responsibility of the decision-maker. The overall optimisation of the total health protection, *i.e.* the final decision on the introduction of long-term countermeasures is therefore the sole responsibility of the decision-maker. It is further concluded that it seems to be an illusory goal to arrive at internationally accepted intervention levels based on an "optimisation" of overall health protection, which includes all the relevant radiological protection and non-radiological protection attributes.

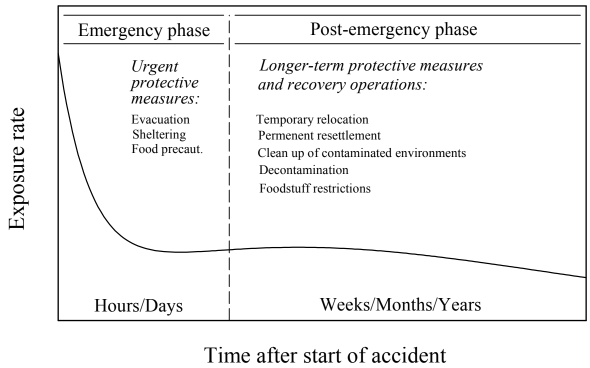
1 INTRODUCTION

In the past 15 years, the Chernobyl and Goiânia accidents resulted in extensive post-emergency phase response. Large amounts of ^{137}Cs were released to the environment during these accidents, leading to a prolonged or quasi-prolonged exposure of the affected populations. The experience gained from these accidents and others have revealed that there is a need for an updated and fully complete system of decision-making on implementation of long-term countermeasures.

An important aim of late phase protective actions is to reduce the likely numbers of cancers as much and as effectively as reasonably possible. However, the total health consequences from long-term exposure situations, and of any countermeasures subsequently implemented, include more than the injuries and increased risks directly attributable to radiation exposure. Stressors, such as the perception of the hazard posed by radiation in the environment and enforced changes of lifestyle, may lead to increases in psychological strain in the effected population. Such increases may in turn lead directly or indirectly to increased illness.

2 LATE PHASE INTERVENTIONS AND COUNTERMEASURES

A nuclear accident is normally divided into three phases: a *pre-release phase* with a time scale of hours/days, a *release phase* with a time scale of hours/days and a *post-release phase* with a time scale of weeks/months/years, depending on the nature of the release. Protective actions to be taken with the purpose of averting radiation exposure from atmospheric releases of radioactive materials are often divided into *precautionary*, *urgent* and *longer-term* protective actions, relating to the three phases of the accident. The *emergency phase* of a nuclear accident covers the pre-release phase, the release phase and part of the post-release phase. Similarly, a radiological accident is normally divided into two phases: an *emergency phase* with a time scale of hours/days and a *post-emergency phase* with a time scale of weeks/months/years. The phases of nuclear and radiological accidents are illustrated in Fig. 1.



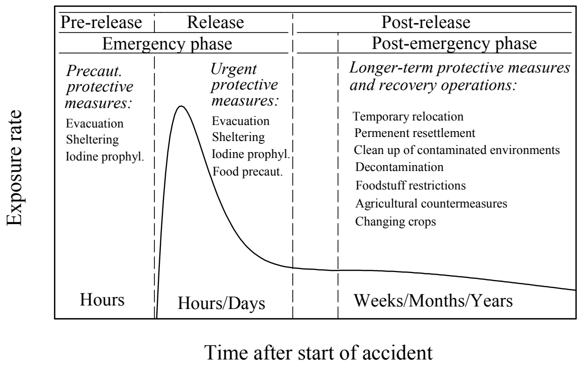


Figure 1. Time phases for introduction of protective actions and protective measures in a radiological (left-hand picture) and a nuclear (right-hand picture) emergency. The longer-term or late phase protective measures are introduced in the post-emergency phase based on measurements.

In the post-release phase it is expected that a reasonably complete picture of radiation and contamination levels and affected areas in the environment become available. In this phase the dominant risks originate from radioactive materials deposited on the ground, mainly from external exposure and ingestion of contaminated foodstuffs, and to a minor degree from inhalation exposure from radioactive materials resuspended in the air. Measured surface contamination density can thus be used to estimate doses from both the external and ingestion exposure pathways and can therefore be used to make decisions about the introduction of countermeasures The major countermeasures in the late phase of an accident are *relocation/resettlement*, *foodstuff restrictions, agricultural countermeasures* and *cleanup* of contaminated land.

2.1 Relocation and resettlement

Relocation refers to the removal of people from the area affected by an accident for a longer period of time (weeks, months or years) to avert exposures from radioactive material deposited on the ground. Relocation and evacuation are fundamentally different actions. In an evacuation the expectation is that people will in general return within a few days, and the accommodation will be of a temporary nature, often in schools or other public buildings. In the case of relocation there is no intention for people to return quickly but rather within months or even years. A distinction can be made between temporary relocation, when a return to the affected area is foreseen within a reasonable time, and permanent resettlement, when return to the area is not expected.

2.1.1 Temporary relocation

Temporary relocation means the movement of people from their homes (or from emergency evacuation centres) to live in temporary accommodation for a period of several months or more. The measure would be taken to prevent radiation exposures from deposited radioactive material, the dose rate being expected to decrease over the period, either naturally or due to decontamination measures. Although there is some time available for the decision on temporary relocation, values for triggering this measure should nevertheless be included in the emergency plans, since they are also needed for the decision on whether people who have been urgently evacuated can return to their homes. The physical risks associated with temporary relocation are relatively small compared with, say, those for evacuation, since the action can be carried out in a controlled and safe manner. However, the upheaval may cause psychological harm to relocated individuals.

2.1.2 Permanent resettlement

It may be the case that, although temporary relocation is deemed unnecessary, residual lifetime doses might be high enough to warrant a permanent resettlement elsewhere. The resettlement criterion can be expressed as the dose averted for the rest of an individual's lifetime. In addition to this criterion for permanent resettlement based on avertable dose, there is a limit to the period of any temporary relocation that can normally be tolerated. The maximum length of this period is dependent on many social and economic factors. Purely economic considerations indicate that continuing temporary relocation costs will begin to exceed permanent resettlement costs between about one and five years. However, social factors, whether increasing discontent with the temporary accommodation and possible related health problems or rather the need to establish settled social patterns, would indicate that the period of temporary relocation should be no more than a year or so.

2.2 Foodstuff interventions

After an accident, the levels of contamination in foods will vary markedly according to many factors, *e.g.* the type of food, the physical and biological half-lives of the radionuclides, soil types, agricultural practices, etc. It is useful to distinguish between two different types of countermeasures, namely foodstuff restrictions/withdrawal and agricultural countermeasures.

2.2.1 Foodstuff restrictions

Withdrawal and substitution of contaminated foodstuffs is a disruptive action. Intervention levels for this countermeasure can be developed according to the principles of justification and optimisation. Where alternative food supplies are readily available, the requirement that banning of foodstuffs be justified is easily satisfied. The major inputs to the selection of these intervention levels would be the collective doses that would be averted per unit mass of foodstuffs and the value placed on the food by society. The need to build and maintain public confidence would also be a major concern in the decision-making process.

2.2.2 Foodstuff countermeasures

The use of more sophisticated agro-technical measures to reduce the levels in food still further than expressed by the intervention levels for banning foodstuffs should be considered. Techniques include the washing of fruit and leafy vegetables and the removal of outer leaves and surfaces of crops to remove surface contamination. Other techniques include the alteration of agricultural practices, for example administering Prussian Blue to livestock to reduce radio-caesium in animal products, the feeding of livestock with uncontaminated feed for a few weeks before slaughter, and growing different crops grown on contaminated soil. Storage of suitable foods can significantly reduce contamination by short-lived radionuclides.

2.3 Cleanup of contaminated areas

Decontamination is, in general, a less disruptive protective measure than long-term closure of areas because, after the cleanup process is completed, some activities can resume. Its purpose is to reduce the external irradiation from deposited activity, reduce the transfer of radioactive material to humans, animals and foodstuffs, and reduce the potential for resuspension and spread of radioactive material.

The effectiveness of decontamination in urban areas depends on a number of factors. Generally, the effectiveness is greater the sooner the decontamination operation is started, as time tends to increase the adhesion of contaminants to surfaces by physical and chemical forces. A wide variety of techniques have been investigated for the cleanup of all types of materials, buildings, equipment and lands, *e.g.* ploughing, removal of surface soil, and physical and chemical separation of radionuclides from soil.

The cleanup of large contaminated areas could be very costly and cause inconvenience to the public. The costs of loading, transport and disposal of wastes arising from the cleanup of large contaminated areas will be a significant fraction of the total decontamination costs.

3 RADIOLOGICAL PROTECTION CRITERIA FOR LATE PHASE INTERVENTIONS

Intervention is required to reduce the existing radiation exposure in a *de facto* situation that is judged to be unsatisfactory from the point of view of radiological protection as is the situation in the late or post-emergency phase of a nuclear or radiological accident. The principles of the System of Radiological Protection for intervention are the *justification of intervention* and the *optimisation of protective measures*. The intervention will achieve an averted dose and a residual post-intervention dose will remain. If the protective actions to avert individual doses have been optimised, the post-intervention dose is not subject to further dose reductions.

The ICRP [8] is recommending *generic reference levels* for intervention and these levels can be expressed in terms of the *existing total annual dose*. These reference levels should be seen as a *conse-*

quential derivation from the existing ICRP principles and as *complementary* to these principles. They are particular useful for interventions against exposures to high natural background radiation, for interventions against exposures to radioactive residues from past activities and for interventions against exposures from long-lived radionuclides in the environment from nuclear or radiological accidents. The generic reference levels should, however, not prevent protective actions from being taken to reduce dominant components of the existing total annual dose. The ICRP as well as other international organisations [3, 4, 5] recommends *specific reference levels* (intervention levels) in terms of *avertable (individual or collective) dose* or derived quantities (*e.g*. Bq/kg)) for specific late phase countermeasures as shown in Table 1. The specific reference levels or intervention levels are generally derived from a generic optimisation in which the only attributes are dose reduction and monetary costs [3, 4].

Table 1. Recommended late phase intervention criteria from international organisations. IAEA criteria for withdrawal of foodstuffs are grouped in category I (fresh milk, vegetables, grain, fruit) and category II (meat, milk products). The indicated IAEA criteria for withdrawal of foodstuffs are valid for ^{137}*Cs- like radionuclides (group 1). The intervention criteria for other nuclide groups e.g.* ^{90}*Sr (group 2) and* ^{239}*Pu (group 3) are a factor of 10 and 100 lower, respectively.*

Late phase Countermeasure	ICRP [3]	IAEA [2, 4, 9]	EU [5, 6]
Temporary relocation	> 10 mSv in a month	> 30 mSv in first month > 10 mSv in subsequent months	> 10 mSv in a month
Permanent resettlement	> 1 Sv in lifetime (70 years)	> 1 Sv in lifetime (70 years)	> 1 Sv in lifetime (70 years)
Foodstuff withdrawal	> 10 mSv in 1 year for a *single* foodstuff > 1,000 - 10,000 Bq/kg (β) > 10 - 100 Bq/kg (α)	> 1,000 - 10,000 Bq/kg (I) > 10,000 - 100,000 Bq/kg (II)	maximum permissible levels of radionuclides in foodstuffs close to the Codex Alimentarius Commission values
Agricultural countermeasures		generic action levels selected from mid-ranges of optimised intervention levels to be identical to the Codex values	
Cleanup of contaminated land	*total* dose reference level of 10 mSv/a cleanup based on optimised level of *avertable* dose	*total* dose reference level of 10 mSv/a cleanup based on optimised level of *avertable* dose	

Generically optimised action levels for foodstuffs are shown in Table 2 [2, 4]. These values have been selected in general towards the middle of each range of optimised action levels and they have deliberately been given the same numerical values as those recommended by the Codex Alimentarius Commission [7] for concentrations of activity in foodstuffs moving in international trade. The levels in Table 2 are strictly action levels since they are not for any specific countermeasure, nor are they expressed in terms of an avertable quantity. Consistency and simplicity in application and compatibility with the guidance of the Codex Aliementarius Commission were important considerations in the selection of specific values.

Table 2. Generic action levels for foodstuffs from the BSS and IAEA [2, 4]. These action levels are identical to the recommended guideline levels from the Codex Alimentarius Commission [7].

<table>
<tr><th colspan="3">Recommended Action Levels ($Bq \cdot kg^{-1}$)</th></tr>
<tr><th>Radionuclides</th><th>Foods destined for general consumption</th><th>Milk, Infant foods and Drinking Water</th></tr>
<tr><td>$^{134,137}Cs$, $^{103,106}Ru$, ^{89}Sr</td><td rowspan="2">1,000</td><td>1,000</td></tr>
<tr><td>^{131}I</td><td rowspan="2">100</td></tr>
<tr><td>^{90}Sr</td><td>100</td></tr>
<tr><td>^{241}Am, $^{238,239}Pu$</td><td>10</td><td>1</td></tr>
</table>

The EU Council has adopted maximum permissible levels for four radionuclide groups in four major food groups as shown in Table 3 [6]. The maximum permissible levels in each nuclide group were derived with considerable safety margins and can therefore be applied independently of the other groups.

Table 3. Maximum permitted levels from "Council Regulation (Euratom) No. 3954/87 of 22/12/1987 laying down maximum permitted levels of radioactive contamination of foodstuffs and of feeding stuffs following a nuclear accident or any other case of radiological emergency" [6].

Radionuclide group	Baby Food	Dairy products	Other foodstuffs	Liquid food	Feeding stuffs
Isotopes of strontium, notably ^{90}Sr	75	125	750	125	-
Isotopes of iodine, notably ^{131}I	150	500	2,000	500	-
α-emitting isotopes of plutonium and trans-plutonium elements, notably ^{239}Pu and ^{241}Am	1	20	80	20	-
All other nuclides with half-life greater than 10 days, notably ^{134}Cs and ^{137}Cs	400	1,000	1,250	1,000	Pig: 1250 Poultry: 2500 Others: 5000

The levels in Table 3 will apply to the placing on the market in the event of any future accident. They will be entered into force by a regulation of the European Commission. The validity of such a regulation will be limited to three months, during which another regulation will be prepared. The pre-established level in Table 3 will then be adjusted if necessary to take into consideration the circumstances of the particular accident.

The current scientific consensus on radiation protection is based on objective assessments of the health risks associated with radiation exposure and on radiological protection attributes of various exposure situations. It should, however, be recognised that this consensus on recommendations of radiation protection should be seen as a decision-aiding tool, and that these recommendations would be used as input to a final decision-making process, which may include other societal concerns and considerations.

4 DECISION-MAKING ON LATE PHASE INTERVENTIONS

In many intervention situations there are considerations, which may not be objectively related to radiological protection that may also need to be taken into account in making decisions about intervention. ICRP consider that these other considerations, which are mainly of a socio-political and cultural nature, may be taken into account in a decision-making process which should be wider than the decision-aiding process for the justification of intervention as all relevant attributes are included, not only radiological protection attributes.

4.1 Radiological protection attributes

Radiological protection attributes are defined as those, which are related to the level of radiological protection achieved and they have been used in developing international numerical guidance on intervention levels for implementing countermeasures to reduce doses after a nuclear or radiological emergency [2, 3, 4]. Thus they include those attributes describing the dose distribution averted and those describing the costs incurred in averting the doses. All these techniques have as their primary objective to clarify, for the people who have to decide on the intervention, the various attributes, to quantify them if this is reasonable and necessary, and to systematize the trade offs between the various attributes.

Attributes, which would clearly be radiological protection related, include those describing benefits from the countermeasure and those describing harm:

- the averted individual and collective radiation risks for the members of the public,
- the individual and collective radiation risks to the workers in carrying out the countermeasure, and
- the monetary cost of the countermeasure.

4.2 Non-radiological protection attributes

Non-radiological protection attributes are defined as those, which are not related to the level of radiological protection achieved by protective measures. It is very difficult to generalize about these attributes, although they can have an important or even overriding influence on the decisions taken.

Most intervention is disruptive to normal social and economic life. Change may cause anxiety, which can be harmful to health and well-being. However, the absence of protective measures can also cause anxiety, which is often exacerbated by a lack of objective information. These effects are non-radiological, are not easily quantifiable, will vary markedly between countries, and in any case will normally have opposing influences on the choices of intervention levels. They include the following attributes:

- the individual and collective physical risks to the public caused by the countermeasure,
- the perception of the hazard posed by the radiation from environmental dispersed radioactive materials,
- psychological impacts,
- the reassurance provided by the implementation of the countermeasure,
- the anxiety caused by its implementation,
- the individual and social disruption resulting from its implementation, and
- political considerations.

Although some of these attributes to a certain extent are related to the level of protection achieved they are all considered to be non-radiological protection attributes. The political input, however, is always deemed to include only non-radiological protection attributes.

4.3 The role of radiological protection in decision-making

Management of protective actions in existing exposure situations is not a radiological protection problem only, which was experienced in the former USSR following the Chernobyl accident. The socio-psychological attributes are important and may in some cases be dominating. Socio-psychological countermeasures are a new category of action, in the sense that social protection philosophy has not yet been developed to fully include their application in such situations, especially those following nuclear or radiological accidents.

Without the introduction of protective actions, most attributes would quantify disadvantages, *e.g.* the existing individual and collective doses. The advantage of intervention is that it may reduce the disadvantageous attributes, for instance averting individual and collective doses, or even get rid of them. Intervention may also introduce advantageous attributes, such us the reassurance produced by the intervention. But intervention will in addition introduce new disadvantageous attributes, *e.g.* the costs, harm and inconveniences introduced by the protective actions.

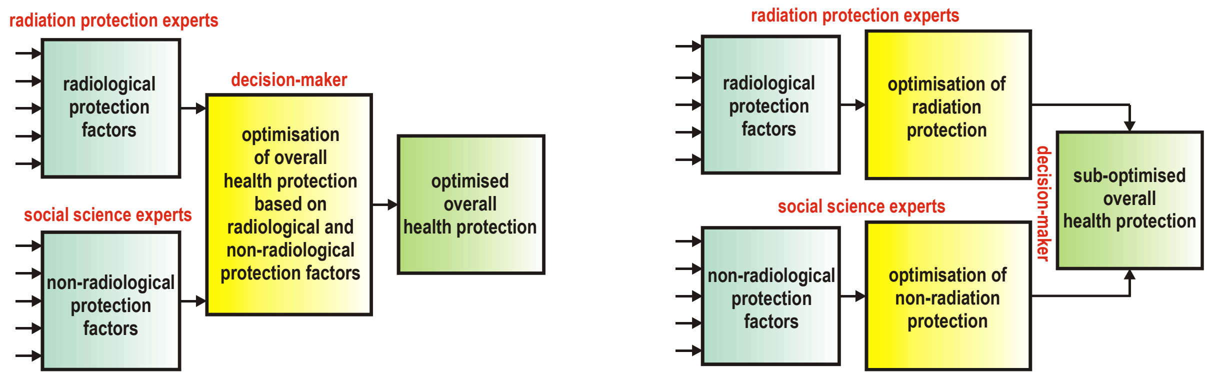


Figure 2. Optimisation vis a vis sub-optimisation of overall health protection. The right-hand picture shows that when radiation and non-radiation protection is optimised separately, the overall health protection might be sub-optimised. Therefore, to achieve an optimised overall health protection, all factors should enter the optimisation (decision-making) process in parallel at the outset.

Explicit guidance is not provided on how psychological, social and other non-radiological attributes should be included in the optimisation of the overall health protection of the affected population. However, the optimisation of radiation protection and psychological and social protection should not be carried out independently, as the overall health protection would depend on both radiological and non-radiological protection attributes as shown in Fig. 2. Combining independent optimisations of radiological and non-radiological protection might lead to a sub-optimised overall health protection as indicated.

5 OUTSTANDING ISSUES AND CONCLUSIONS

Many intervention situations are integrated into the human habitat and the ICRP anticipates that the decision-making process will include the participation of relevant stakeholders, rather than radiological protection specialists alone. Such a process may take account of attributes other than those directly related to radiological protection. The objective is that those concerned with the situation should be involved and be given the opportunity to participate in the decision-making process. This is especially important in long-term intervention after an accident and, in particular, in the definition of normality of the situation. During more than a decade these issues have been discussed within the radiation protection community and elsewhere and some observations from these discussions are given below.

(1) It has been claimed, that there has been a tendency for the radiation protection community to try and take the leading role in every situation where radiation protection has a role to play, even when radiation protection issues rarely would be the most important.

(2) In line herewith, members of the radiation protection community, when being criticized for including some of the non-radiological attributes in generic optimisation of protective actions, have argued that “if we don’t, nobody will”, *i.e.* that societal aspects should be integrated in radiation protection.

(3) It has been argued that issuing generic numerical guidance on intervention from the international radiation protection organisations is highly questionable, because the inclusion of other factors in the decision-making process probably would modify the generic levels and because those using the generic levels might pay no attention to the various caveats on their derivation.

(4) Strong arguments have been put forward on the importance and usefulness of gaining wide acceptance of intervention levels and international agencies are encouraged to do so, as differences between countries could undermine national policies and become the source of much public and political concern and disruption following an accident.

(5) The experience gained after the Chernobyl and Goiânia accidents and elsewhere shows that major differences exist between generic intervention levels developed internationally and the actual levels used in post accident management. Dose limits for practices and even lower levels have been used as intervention levels, and it has been argued that this is fully in accord

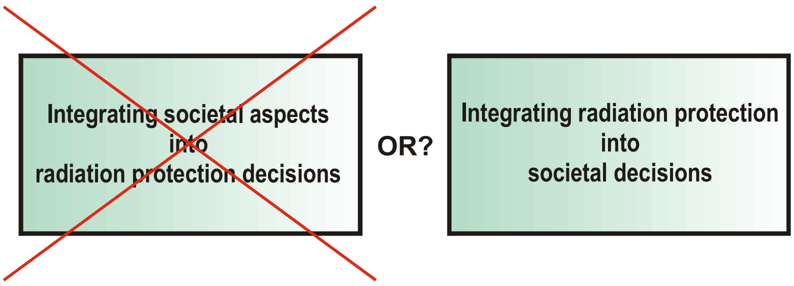
with the principles of intervention if all relevant protection attributes have been given due weight in the decision-making process. It has also been argued that in the longer term after an accident, it is reasonable for the population to demand the application of the same standards of protection as the rest of the (unaffected) population.

(6) The involvement of stakeholders in the decision-making process in post accident management have increasingly been explored over the last decade by the radiation protection community, especially within the NEA/OECD and lately also in the preparation of the upcoming general recommendations from ICRP [10].

Each of these observations are addressed and elaborated upon, in particular from the viewpoints of radiation protection and the role of radiation protection in post accident management of a nuclear or radiological emergency.

(ad 1) This observation, how plausible it ever may sound, tends to overlook that the radiation protection community only acts when radiation is involved and then only on radiation protection issues. More seriously, for radiation protection issues to be "rarely the most important", presupposes that it is possible to weigh the different non-radiological protection attributes against the radiological protection attributes, which still is not possible due to lack of both methodology and data. Therefore, the claim that the radiation community try to take the leading role whenever radiation protection has a role to play and that radiation protection issues rarely are the most important is loosely founded.

(ad 2) This observation is more straightforward. The inclusion of all relevant attributes into the decision-making process could never be the preserve of one or another technical community, it is solely the role of the decision-maker with inputs from the relevant parts of society, including inputs from the radiation protection community as indicated in the figure below. Experts in radiation protection or any other experts are <u>not</u> decision-makers and, consequently, the right-hand picture should form the basis for decisions in post accident management.



(ad 3) This observation on the issuing of numerical guidance on intervention levels from international organisations seems to neglect that it is of utmost importance that societies without a strong radiation protection infrastructure needs numerical guidance that can be used for quick decisions which are not far off an "optimum" radiation protection solution. As one of the major stakeholders in the decision-making process, the radiation protection community has an obligation to recommend generic levels from a radiation protection point of view. Even if these generic levels probably will be altered in a final decision-making process, such alterations can go in both directions, not only towards intervention levels lower than the generic ones.

(ad 4) The observation on the importance of gaining wide international acceptance of intervention levels to avoid any undermining of national policies that could result in public and political concern and disruption after an accident is fully appreciated. However, the different protection attributes entering the decision-making process are not all independent, in some cases they even strongly depend on each other. For instance, the level of socio-psychological impact would depend not only on the presence of radiation but to a large extent on other factors such as the attitude of the mass media, the political climate and the general level of information in the population. It seems therefore to be illusory to arrive at internationally accepted intervention levels based upon an overall "optimisation" that includes all relevant protection attributes, because differences between countries at the cultural, political and development level might result in quite different weighting of the different attributes.

(ad 5) The observation that the use of dose limits as intervention levels is fully in accordance with the principles of intervention if all relevant factors have been included in the decision-making process seems to neglect that weighing the different attributes in an overall optimisation (decision-making) process might result in levels of intervention, which are higher than the generically optimised intervention levels, not by default lower. Furthermore, the argument that it is reasonable for the affected population to demand the same standard of (radiation) protection as the rest of the population, *i.e.* that the dose limits for practices should apply also in accident situations, neglects that after a severe accident like Chernobyl this goal might not at all be feasible as there will be bounds to the resources a society may be willing, or able, to commit to intervention to protect the public. Additionally, it would seem rather strange if a national authority should place much more effort and resources into avoiding a radiation induced cancer as it does into avoiding cancers from other causes.

(ad 6) The issue on stakeholder involvement should be seen in the larger context of a democratic decision-making process in which all bodies most directly concerned would have a role to play. The signals from the ICRP in developing their new recommendations indicate that the Commission in future considers the possibility of involving stakeholders in the process of optimisation in determining, or negotiating, the best level of protection in the circumstances [10]. However, it still is to be decided if and how the new ICRP recommendations will deal with this degree of societal process. The question therefore remains if and how stakeholders would be involved in the development of standards to be used in, *e.g.*, post accident management. The consequences of integrating societal aspects into the radiological protection framework would in fact mean that the ICRP would enter the field of decision-making, which appears to be wrong as the radiation protection community has *no* mandate to make societal decisions as already mentioned. An often overlooked and maybe forgotten issue is the fact that the radiation protection community itself has a role as stakeholder within the larger decision-making process. As such, the radiation protection community has a natural obligation to give advice and guidance on radiation protection matters on a scientific basis. Equally important, the radiation protection community also has the obligation to object if protective measures were to be introduced as mainly radiation protection measures when it is obvious that they are not.

From past experience it is evident that a methodology is needed in which all relevant protection attributes can be included in the decision-making process to reach a final (optimised) decision on countermeasures in post accident management. During more than a decade a number of research projects have been conducted on the role of socio-psychological factors in the implementation of protective actions in the late phase of an accident, but no satisfactory instrument have emerged from these research programs as to how radiological and non-radiological attributes can be weighed and combined to achieve an optimised protection of the populations affected. Obviously, further research on these issues is necessary before only a contour of a solution can be seen.

Any revised system of public radiation protection in a nuclear or radiological emergency must have a sound technical basis and be understandable, explainable and acceptable to the public and the decision-makers. Therefore, a common language explanation should be developed for the public and public officials that clearly state the risks of radiation exposure and what actions are appropriate and inappropriate, and what is "safe". The concepts of "safe" and "return to normality" should be developed together with intervention criteria, disengaged from the linear non-threshold risk hypothesis, as 'safe' easily can be in accordance with 'non-zero risk'. One practicable way could be the use of the concept "no observable adverse radiation induced health effects to be expected".

6 REFERENCES

[1] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, *1990 Recommendations of the International Commission on Radiological Protection*. Publication 60, Pergamon Press, Oxford, New York, Frankfurt, Seoul, Sydney, Tokyo (1991).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, *International Basic Safety Standards for Protection Against Radiation and for the Safety of Radiation Sources*. Safety Series No. 115, IAEA, Vienna (1996).

[3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, *Principles for Intervention for Protection of the Public in a Radiological Emergency.* Publication 63, Pergamon Press, Oxford, New York, Seoul, Tokyo (1993).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, *Intervention Criteria in a Nuclear or Radiation Emergency.* Safety Series No. 109, IAEA, Vienna (1994).

[5] COMMISSION OF THE EUROPEAN COMMUNITIES, *Radiation Protection Principles for Relocation and Return of People in the Event of Accidental Releases of Radioactive Materials.* Radiation Protection 64, Doc. XI-027/93, Luxembourg (1993).

[6] Council Regulation (EURATOM) No. 3954/87 of 22/12/1987 laying down maximum permitted levels of radioactive contamination of foodstuffs and of feeding stuffs following a nuclear accident or any other case of radiological emergency. Official Journal of the European Communities, L146 of 30/12/1987.

[7] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS/WORLD HEALTH ORGANIZATION, Codes Alimentarius, General Requirements, Section 6.2, Guideline Levels for Radionuclides in Foods Following Accidental Nuclear Contamination, Joint FAO/WHO Food Standards Programme, Rome (1991).

[8] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection of the Public in Situations of Prolonged Exposure. Publication 82, Pergamon (2000).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, *Remediation of Areas Contaminated by Past Activities and Accidents.* Draft Safety Requirements, Vienna (2003).

[10] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, *The evolution of the new system of radiological protection: the justification for new ICRP recommendations.* Journal of Radiological Protection, **23** (2003) 129 - 142.